UCRL-JC-119870 Ext Abs

MTF OF CSI SCINTILLATOR FROM TRANSPORT OF SECONDARY X-RAYS*, C.M. Logan, Lawrence Livermore National Laboratory, J.S. Gordon, J.M. Hernández, D.L Lewis, and L.N. Mascio

Cesium iodide with thallium dopant (CsI) has attractive features for use as a scintillator in medical imaging, especially mammography. Amongst its desirable properties, it that it can be induced to grow in a columnar structure. This structure has been shown to reduce the spreading of light within the scintillator. However, secondary x-ray transport is not deterred by grain boundaries. The resulting energy transport away from the primary interaction site degrades spatial resolution irrespective of a columnar structure. In order to understand and quantify this effect, we applied Monte Carlo methods to compute the modulation transfer function from secondary x-ray transport (MTF_x) in CsI. From these calculations we derived modulation transfer functions arising from secondary x-ray transport (MTF_x). We have three main results.

- Below the K-edges of Cs and I, secondary x-ray transport has only a small impact on MTF_x.
- X-ray return from the fiber optic backing is not an important contributor to MTF_x compared to other x-ray transport.
- Above the K-edges of CsI, less than 50% of the incident x-ray energy is deposited at the primary interaction site. This degrades MTF_x to about 0.7 at 5 lp/mm.

Secondary x-ray transport must be considered in the choice of x-ray spectra for digital mammography.

*Work performed under auspices of the U.S. Department of Energy by the Lawrence Livermore National Laboratory under contract No. W-7405-ENG-48.

AAPM supporting material......

MTF OF CSI SCINTILLATOR FROM TRANSPORT OF SECONDARY X-RAYS,

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Cesium iodide with thallium dopant (CsI) has attractive features for use as a scintillator in medical imaging, especially mammography. It has high light yield and rapid light emission. It's light is well matched to fiber optics and silicon detection devices. And, it likes to grow in a columnar structure when deposited from a vapor onto an appropriate substrate. This structure has been shown to reduce the spreading of light within the scintillator. This offers hope of overcoming the traditional compromise between x-ray stopping power (thickness) and spatial resolution. Some consider development of viable CsI to be essential to the success of digital mammography.

We used the TART Monte Carlo code and the ENDL Evaluated Nuclear Data Library for this work. Problems were run on a Cray YMP computer. Problem CPU times were a few minutes. All runs were performed for a million source photons. Statistical uncertainty does not affect any of the results.

We zoned the problem with cylindrical symmetry. All source photons were directed along the axis of symmetry. Each run was for a single monochromatic x-ray energy. We performed fifteen runs as shown below:

Thickness (µm)	111	111	111	111	111	111	111	150	150	150	150	200	200	200	200
Energy (keV)	25	25	33	37	40	40	45	25	33	37	45	25	33	37	45
fiber optic	yes	no	yes	yes	yes	no	yes	yes	yes	yes	yes	yes	yes	yes	yes

In order to generate MTF_x, we developed functional fits to the integral of the radial energy deposition. An example of this is given in Figure 1.

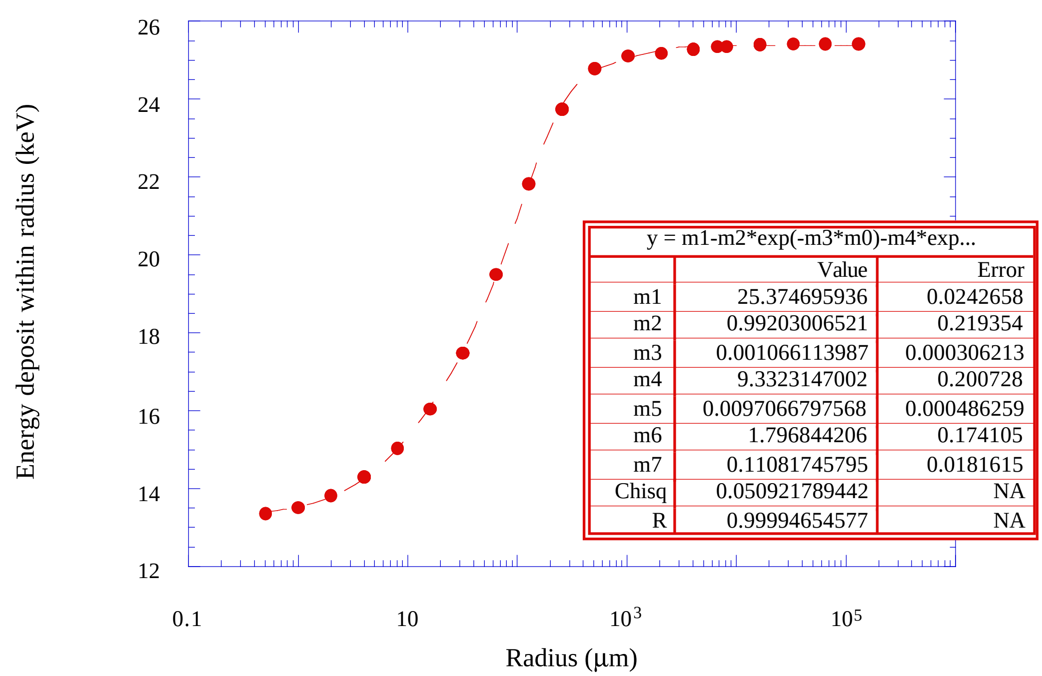

Figure 1. Energy deposition by 37 keV x-rays in 150 µm of CsI on glass

The functional fits were used to generate a digital image of the energy deposition using the fitted expressions. This image was 1024x1024 pixels with a pixel size of 1 µm. We used SCIL/Image, a commercial image processing package, to take the magnitude of the two-dimensional Fourier transform of the digital image. From the resulting (transformed) image we extracted a line of pixels from the origin to an edge and normalized. We converted frequency to lp/mm by dividing by the image size of 1.024 mm. Figure 2 presents results for a CsI thickness of 150 µm and four different x-ray energies. The dramatic effect of secondary x-ray transport is evident above the K-edges of the scintillator.

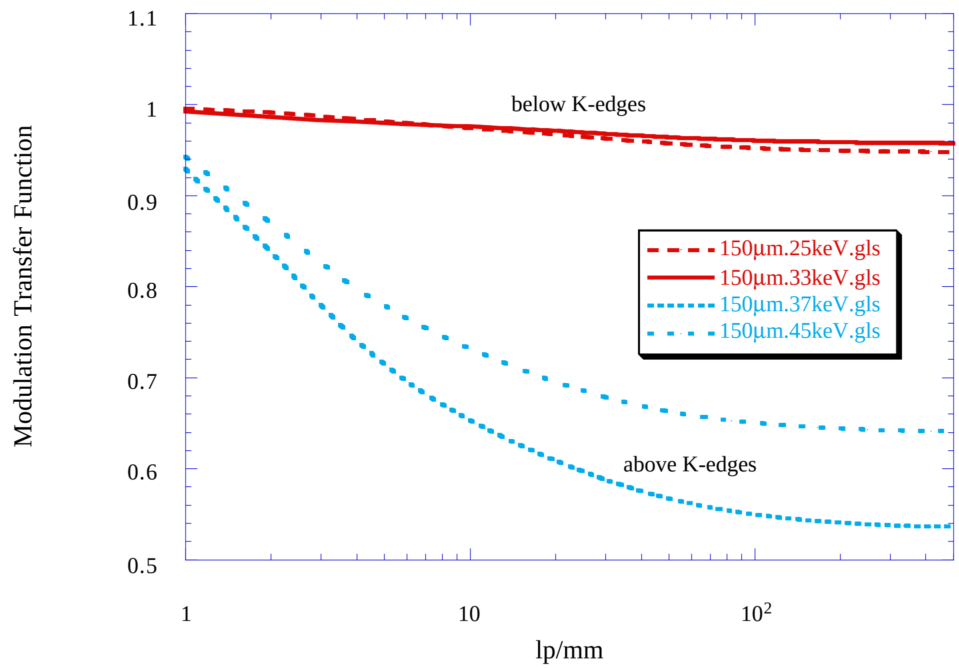

Figure 2. MTF for 150 µm of CsI at various x-ray energies

We make three principle observations:

- Below the K-edges of Cs and I, secondary x-ray transport has only a small impact on MTF_x.
- X-ray return from the fiber optic backing is not an important contributor to MTF_x compared to other x-ray transport.
- Above the K-edges of CsI, less than 50% of the incident x-ray energy is deposited at the primary interaction site. This degrades MTF_x to about 0.7 at 5 lp/mm.

From this we conclude:

- *Spectra rich in photons above 37 keV should be employed with caution in mammography systems utilizing columnar CsI.*